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*Annual Report*

*Covering the Period August 15, 1973 through August 15, 1974*

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**TECHNOLOGY TRANSFER — TRANSPORTATION**

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CONTRACT NASw-2455



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## PREFACE

Much of the wealth of scientific and technological information developed under the sponsorship of the National Aeronautics and Space Administration has proved useful and beneficial for mankind when applied to nonspace problems. To expedite this broad utilization of advanced technology, NASA initiated its Technology Utilization Program with the overall objectives of transferring aerospace-derived technology for the solution of important technological problems in the areas of public transportation, housing, environment, and biomedicine. To assist NASA in achieving this transfer of knowledge, key research organizations throughout the country have established Technology Application Teams. These teams work actively in specified areas of public concern, helping to match problem and solution, and following through to ensure the most efficient utilization of the transferred technology.

SRI has established such a Technology Applications Team with transportation as its main area of concern. Members of the SRI team during this report period were:

Dr. Tom Anyos, Director

Mrs. Ruth Lizak, Research Associate

Mr. James Wilhelm, Research Engineer

Mr. Kenneth Hirschberg, Research Engineer

The core team also has the capability of drawing on the extensive and varied competence of SRI's staff for solutions or commentary on specified technical problems. This ability has allowed the team to match widely varying areas of NASA-derived technology to areas of public concern outside the team's direct expertise.

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This is the final annual report under Contract NASw-2455, covering the period August 15, 1973, through August 15, 1974.

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## I INTRODUCTION

The technological advances achieved by the National Aeronautics and Space Administration as it fulfills its mission of exploring space have proved highly useful when applied to many earthbound problems. Advances in techniques relating to biomedicine, environment, transportation, and housing have been applied to public sector problems through the efforts of NASA's Technology Utilization Office. It is the mission and goal of this office to derive the most beneficial utilization of all advanced technologies developed under NASA auspices.

The transfer of technology usually does not occur spontaneously. The diffusion of new information is a slow process and if not handled in a capable manner may never occur. To assist the Technology Utilization Office in transferring technology in the most expeditious manner, and to ensure its proper utilization, a number of key research organizations within the United States have established Technology Applications teams. These teams, working closely with NASA research scientists and technology utilization specialists, identify solutions derived from NASA technology. It has long been shown that the active approach to this transfer of technology, or active problem/solution matching, as embodied by the team concept is the most effective tool for the dissemination and promulgation of advanced concepts and devices.

The mission of the Technology Applications Team at SRI is to seek the solution to problems in the area of public transportation. In its effort to fulfill that mission, the SRI team has developed a number of techniques and methodologies for decreasing the time gap between the development of a new technology and its commercial availability. For

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this reason the team has been able to influence positively the movement of newly developed technologies across industrial, interdisciplinary and regional boundaries. Highlights of this work are reported here.



## II APPLICATIONS OF NASA TECHNOLOGY

In an effort to develop effective transfers of high public impact, the SRI team narrowed its focus significantly over this past year. After detailed and objective analysis, the priority on many of the problems pursued actively in the past (especially in the railroad area) was either eliminated or greatly reduced. Highlights of the most significant problems are described in this report.

### An Improved Zinc-Rich Coating for Corrosion Protection

Corrosion of bridges in coastal areas is markedly accelerated by the exposure to salt spray. These bridges are currently protected with zinc-rich coatings with demonstrated lifetimes of approximately five to seven years. After that period, the adhesive bond between the coating and bridge fails and corrosion begins.

The SRI team learned of this problem through its contacts with California Department of Transportation and other users. A survey of the literature uncovered a zinc-rich coating with potassium silicate binder, developed at NASA's Goddard Space Flight Center to protect gantries at the launch site. This coating appeared to demonstrate adhesive characteristics superior to any commercially available coating. The team contacted GSFC and arranged for steel samples coated with this paint to be sent to California for testing.

Ten 3 x 6 inch steel plates were coated with the NASA formulation. Seven of the ten were given surface finishes of urethane-polyester, epoxy, polyvinyl acetate, chlorinated rubber, or polyvinyl chloride. The plates were placed in the salt spray chamber of California's Department of

Transportation on March 11, 1974. Once a month the plates were removed and examined by California test laboratory personnel and by the SRI team.

At the end of the second month (1430 hours), three plates showed some blistering of the surface finish. These plates were surface coated with urethane-polyester, epoxy, and a polyvinyl acetate. After four months (2900 hours) one additional plate--with a polyvinyl chloride finish--began to blister. It also exhibited traces of rust.

The remaining six plates held well for the entire test, which lasted 5308 hours. Figure 1 shows three conditions of one plate: (a) topcoated with 4 mils vinyl acetate over 2 mils of zinc-rich primer as it came from the salt spray chamber, (b) with finish coat and primer removed, and (c) with 3x magnification. The plate showed no signs of blistering or rust. According to California DoT's R. F. Stratfull, a 3000 hour endurance denotes superiority and is the upper limit of their test program. NAPCO, a manufacturer of zinc-based coatings, places its test requirement at 4000 hours.

Corrosion specialists at the California DoT laboratory were very favorably impressed with the performance of the NASA coating. The results were related to a representative of the California Division of Bay Toll Crossings who suggested the coating be applied to a test section of the Golden Gate Bridge. Arrangements are currently being made by the SRI team to obtain the necessary zinc coating and set a date for application. In addition, the team has requested permission from NASA HQ to perform a market survey on corrosion resistant paints.

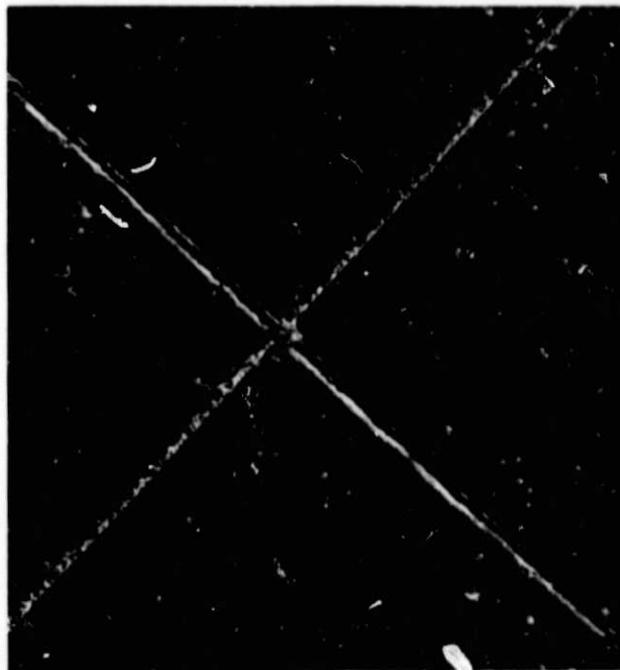
Contact with GSFC revealed that a Houston-based paint company, Preservo Paint Company, has been working with Dr. John Schutt, GSFC, in the development of this paint. Preservo Paint has been contacted and



(a) WITH VINYL ACETATE  
FINISH COAT



(b) FINISH COAT AND ZINC  
PRIMER REMOVED



(c) SAME AS (b), MAGNIFICATION 3X

SA 3670-2

FIGURE 1 NASA's POTASSIUM SILICATE ZINC DUST COATING AFTER  
5300-HOUR SALT SPRAY TEST—NO SIGN OF CORROSION

sample quantities for the Golden Gate Bridge test will be obtained. Installation on the bridge is tentatively scheduled for early 1975.

The SRI team feels that this NASA technology has strong potential for transfer and will benefit society by keeping bridges corrosion free longer, thus greatly reducing maintenance costs and increasing safety.

#### Streamlined Truck Bodies to Reduce Air Drag and Increase Fuel Economy

Present-day truck shapes consider air drag factors; however, these factors are balanced with the concept of "cube." The term "cube" relates to the packing factor on a truck, and simply stated, points out that square boxes do not fit rounded corners.

In the light of current energy considerations, the cube concept is no longer as valid as in previous years. A number of truck manufacturers have looked toward new, streamlined design concepts to minimize air drag and increase fuel efficiency.

The SRI team learned that engineers at the Flight Research Center, Edwards AFB have been working, under U. S. DoT funding, on improved aerodynamic shapes for semitrailer trucks. Results to date have shown that with only minimal modification of existing truck design, frictional drag can be reduced over 50% resulting in fuel savings of over 30% at normal operating speeds.

A visit to the Flight Research Center enabled the team to gather more information and witness actual air drag tests. Figure 2 shows the dramatic improvement in air flow (made visible by the addition of diatomaceous earth to the air stream) when an aerodynamic air deflector is attached to the truck cab. Figure 3 illustrates other deflector shapes under study.

FRC personnel continue their testing and design work. With the help



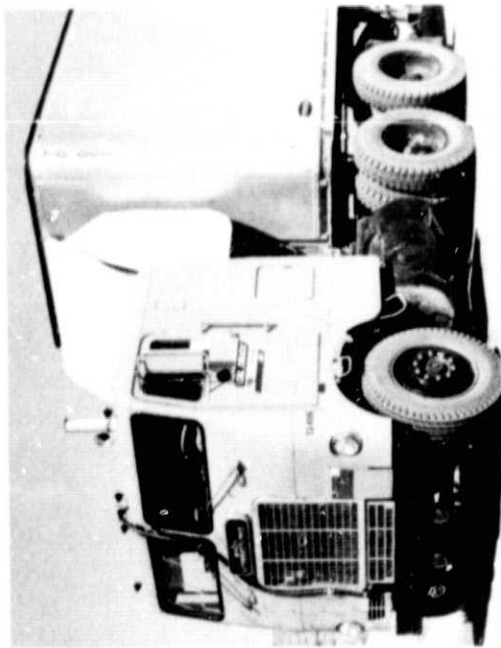
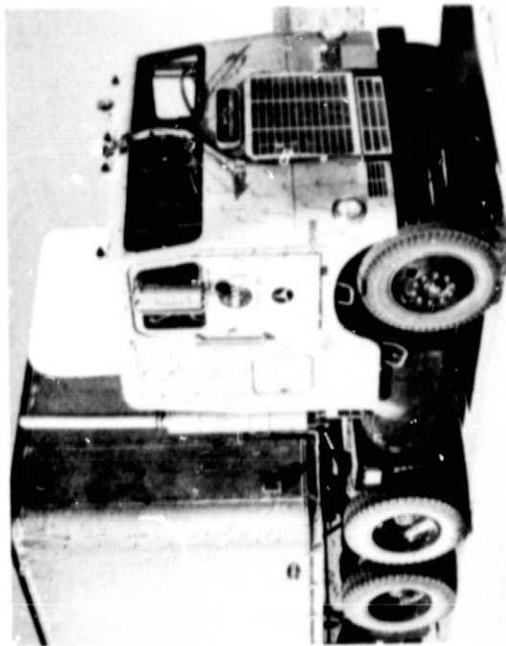
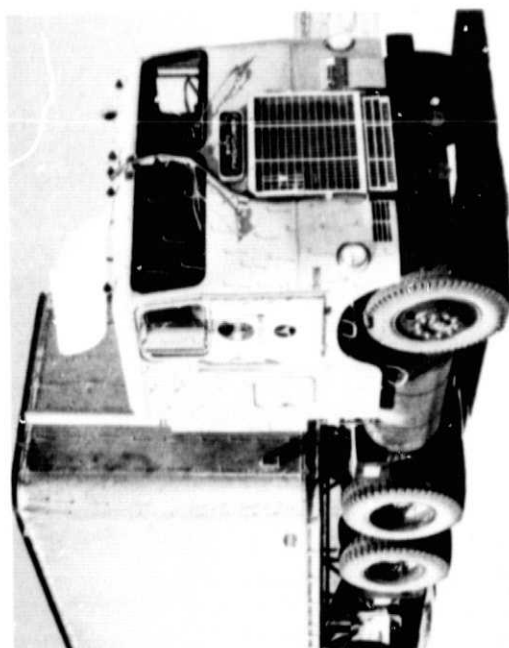
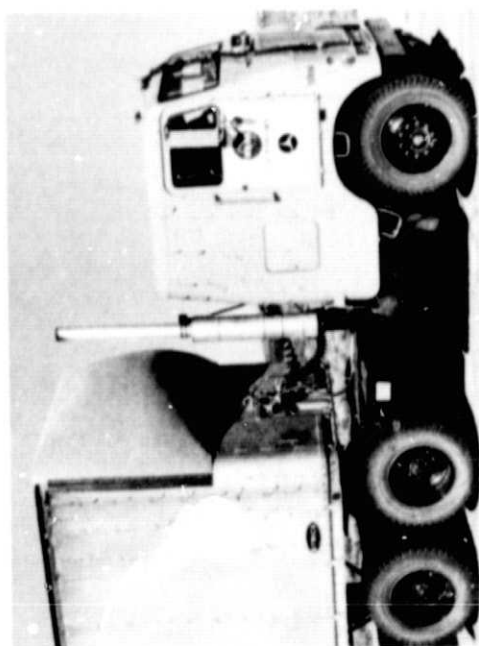
(a) TRUCK WITHOUT DEFLECTOR; NOTE TURBULENCE OVER CAB



(b) TRUCK WITH DEFLECTOR INSTALLED; NOTE SMOOTH AIRFLOW OVER TOP

SA-3670-3

FIGURE 2 EFFECT OF AERODYNAMIC DEFLECTOR ON AIR TURBULENCE



SA-3670-4

FIGURE 3 EXPERIMENTAL AERODYNAMIC DEFLECTORS

of the SRI team, NASA TU, and DoT, they hope to be able to expand their role in maximizing fuel efficiency without significantly altering interior cube (load capability). Further funding will be sought from DoT and other sources by the SRI team to continue this important work.

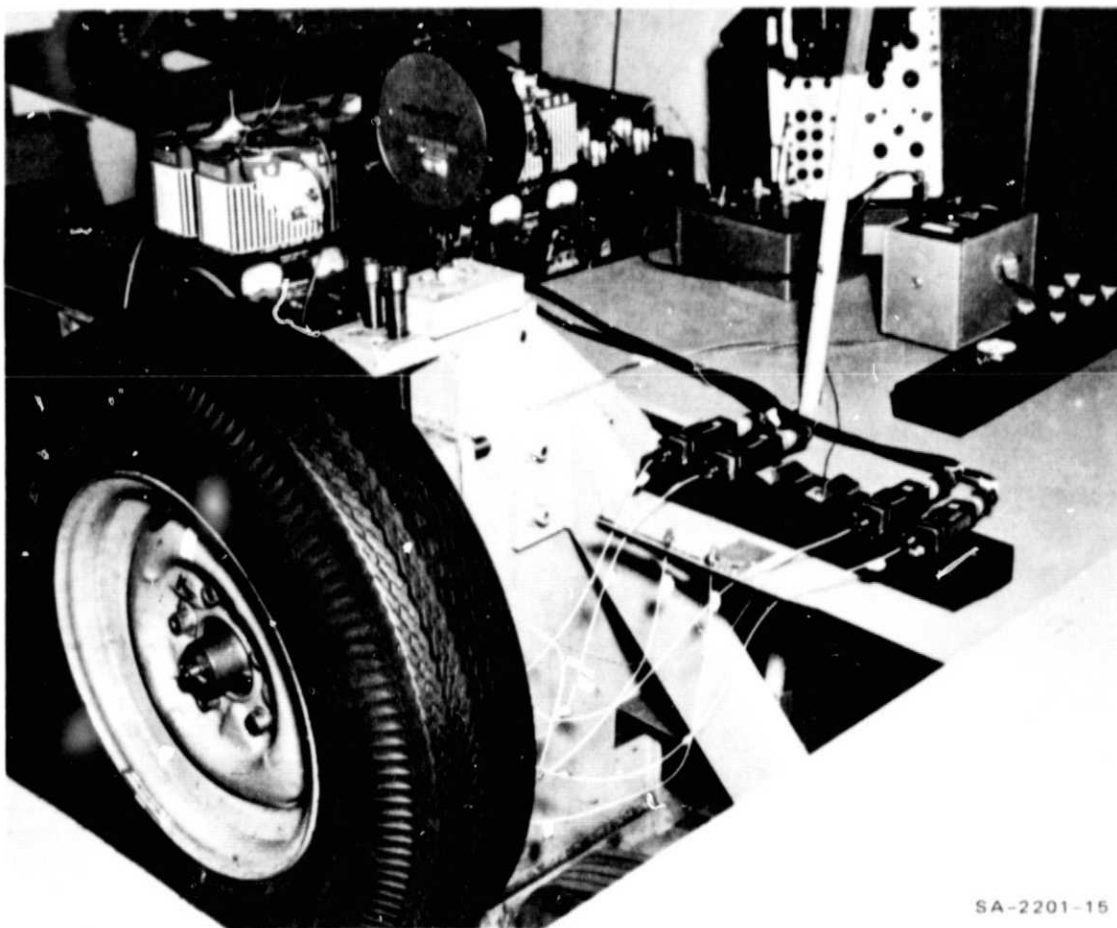
#### More Efficient Brakes for Light Trucks and Other Vehicles

A significant problem identified by the SRI team was the need for better brakes for use on light trucks, buses and other vehicles. Although adequate for today's needs, commercial brakes that are currently available exhibit excessive wear when used in applications requiring a large number of stops and starts, such as in postal vehicle service, delivery trucks, and buses. With maintenance costs steadily increasing, any alternative to frequent brake lining replacement seemed highly desirable.

The team was aware of research under way at NASA-Ames on improved friction materials for SST brake linings. When approached by team members, the Ames scientists agreed to consider the problems involved with other vehicles. Specifications for bus and postal vehicle brakes were delivered to Ames along with samples of then currently used brake shoes.

Comparative friction and wear testing was accomplished to determine feasibility. With a Friction Assessment Screening Test Dynamometer (see Figure 4), the Ames-developed material was compared to the best available commercial material used in the applications under consideration. Results of these tests showed the Ames material, which incorporated a relatively expensive high-temperature polymer, to be two to eight times more efficient than the commercially available materials tested.

Based on these results, a development program was initiated to obtain an optimal formulation for brake linings. As a result of this program,



SA-2201-15

FIGURE 4 LABORATORY TEST OF NASA'S FRICTION MATERIAL



two formulations were developed: one was to exhibit maximum improvement, the other was to be the most cost effective while still maintaining an improvement in brake wear characteristics.

A progress report was prepared in August 1974 by Mr. Joseph A. Mansfield of Ames Research Center. Quoting from this report, it is learned that the optimal cost-effective formulation exhibits "an essentially constant coefficient of friction with temperature to 650<sup>0</sup>F (as high as thus far measured), with an average coefficient of approximately 0.34; a trend in the wear rate of becoming smaller (compared to the standard) as the temperature increases; the wear is equal to the standard at low temperatures and the departure from the standard is approximately 40 percent by 650<sup>0</sup>F; the average improvement in wear obtained over the temperature range of 400 to 650<sup>0</sup>F was in excess of 32 percent.

These properties were achieved solely through the replacement of asbestos by a particular potassium titanate fiber and through formulation adjustments from the optimized standard. Optimization is not now complete. Potassium titanate exhibits a number of superior properties. Aside from no detectable weight loss through 1000<sup>0</sup>C, X-ray studies indicate no detrimental changes through 1000<sup>0</sup>C (for example, products of thermal exposure are no harder than unheated material). While we would surmise that the entire toxicity picture is incomplete, currently available evidence suggests the material acts as an inert substance and does not exhibit carcinogenic tendency.

The second type of substitution is more expensive because the standard phenolic binder is replaced by a more stable but costlier counterpart, although the binder has the potential of providing improved properties. However, the binder is sufficiently distinct from phenolics that the first step of fabricating a satisfactory composite requires substantial experimentation, and further processing work will be required before a satis-

factory composite is formed. Nevertheless improved wear rates at high temperatures have been obtained, and the friction coefficient is comparatively high in both the high temperature regions and, importantly, in the lower temperature region. High friction at low temperature is important because the binder serves a basic function of the modifiers, and the possibility of reducing or eliminating standard modifiers is significant in reducing fabrication problems. Part of the difficulty accompanying the use of the new binder has been that its higher required cure temperatures seriously degrade the standard organic modifiers. Current work is following the line of modifier reduction."

Latest reports from Ames indicate that testing of the final version of the improved lining materials is scheduled for completion in January 1975. At that time, the SRI team, working with Ames scientists, will assist in initiating field trials of the new materials. Lightweight trucks will be fitted with the Ames materials and will run on test tracks to determine the effectiveness of the new materials under field conditions. When the results of these tests are available, the SRI team will assume its marketing function and involve the private sector (i.e., brake manufacturers) for the fabrication and sale of these new linings. In the absence of any unanticipated setbacks, these linings should be commercially available by the fall of 1975.

#### New Devices for Ensuring Rail and Railcar Wheel Safety

##### Roller Bearing Failure Detector

Railroads are currently effecting the changeover from the commonly used journal bearing to the more efficient roller bearing. Although much has been gained by the change from an operational standpoint, unanticipated problems have also surfaced. After periods of wear, or in the case of undetected flaws, all bearings will fail. However, unlike

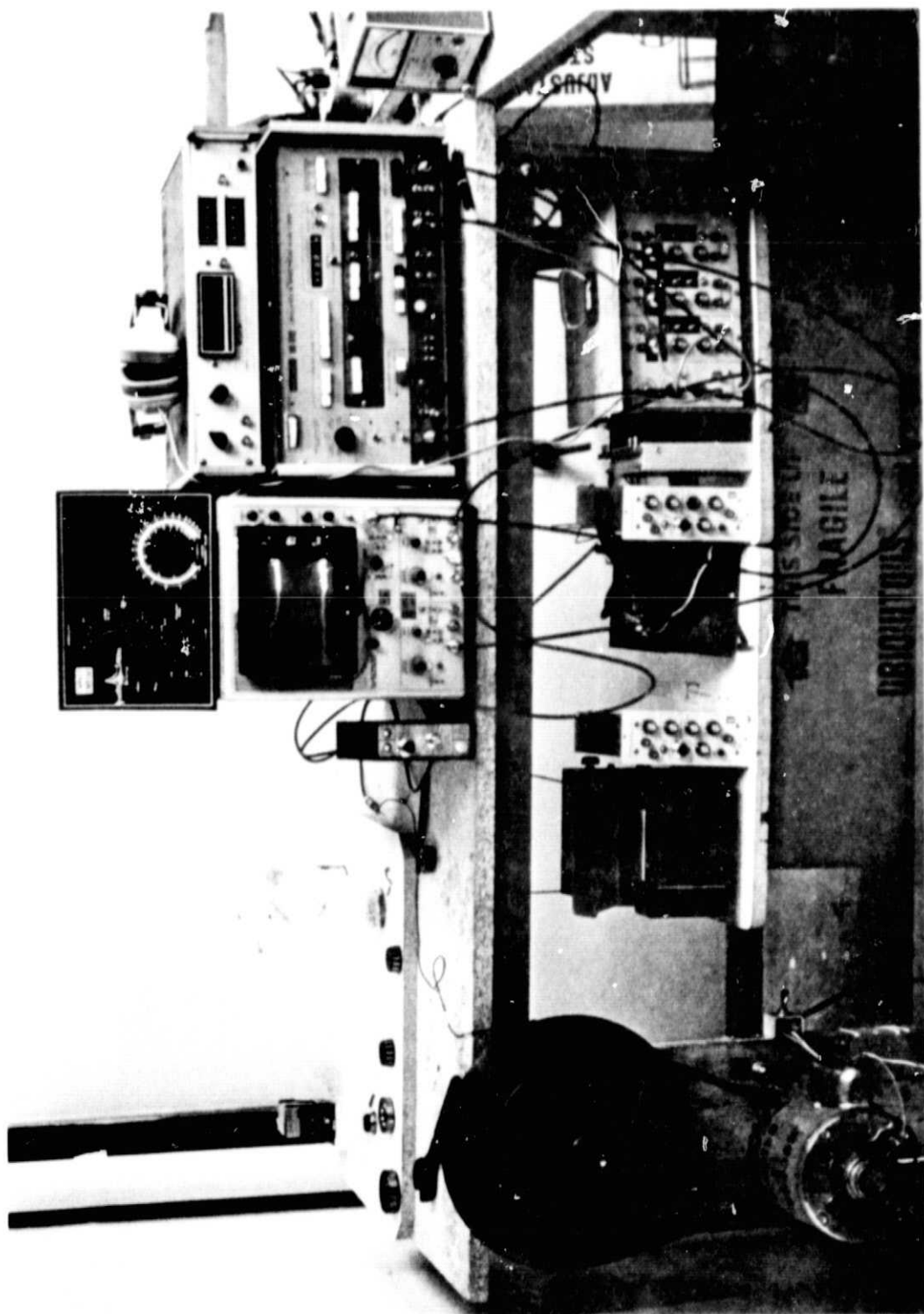
journal bearings, roller bearings will not exhibit a long temperature rise prior to failure, and thus their impending failure will not be detected by standard techniques. This inability to detect incipient bearing failure has been identified as one cause in railcar derailments.

When the SRI team learned of this problem, it reviewed available NASA literature in the nondestructive testing field and uncovered an ultrasonic technique used by NASA scientists for the early warning of roller bearing failure (NASA Tech Briefs 72-10494 and 72-10689). The technique relies upon the fact that bearing defects excite the resonant frequency of the rolling elements (generally in the high frequency range of the spectrum) as they impact the defects. The rate of impact and character of excitation determine the type of defect:

<u>Carrier</u>	<u>Modulation</u>	<u>Condition</u>
Low	None	Excellent
Relatively high	Ball defect signal	Ball defect
Relatively high	Race defect signal	Race defect
Relatively high	Random character	Initial surface defect

The application of this technique for the identification of roller bearing failures in railcars was initiated through an adaptive engineering program cofunded by the Transportation Systems Center (TSC) of the U. S. Department of Transportation and the NASA TU Office. The program is being conducted by the Shaker Research Corporation, Latham, New York.

During the course of this program, key failure modes in rolling element bearings in railcars were identified, fault signatures were obtained ultrasonically, and an electronic breadboard model was constructed (Figure 5). Completion of the field testing of the model and of the design for a field device is expected by midsummer of 1975.



SA-2201-18

FIGURE 5 PROTOTYPE MODEL OF THE NASA-SHAKER ROLLER BEARING FAILURE DETECTOR

Marketing of the device will follow with the SRI team assisting as required. The estimated market price of this device is under \$500 per unit.

During the past year, the team has maintained close liaison with the Shaker Corporation, the Association of American Railroads, and the Transportation Systems Center. As a result of these contacts, the team was able to arrange for the AAR to supply sample bearings for testing by Shaker, and through the AAR, has requested that the Delaware & Hudson Railway Company supply a truck for use in field testing.

All future activity will be limited to brief follow-on contacts to ensure the smooth progress of the program. The team believes it has generated sufficient visibility for the technology that, once adapted, it will rapidly transfer on its own, in the form of a commercially available instrument.

#### Detection of Residual Stress in Track and Wheels

The problem of residual stress buildup in railroad track and railcar wheels was brought to the attention of the SRI team by the Federal Railroad Administration (FRA). Stresses in track are caused by maintenance work done at different times and at different temperatures; in wheels, they are caused by friction braking. Stress buildup in either rail or wheel can lead to failure and subsequent derailment.

During a visit to NASA's Marshall Space Flight Center, the team learned of an ultrasonic technique being developed to detect stress in aluminum. The principal researcher, Mr. Waymon Clotfelter, felt that the approach could be applied to steel.

A lightweight ultrasonic instrument was designed and fabricated from the NASA concept. The instrument was tested for its ability to differentiate between stressed and unstressed steel. Its satisfactory performance reinforced the results of an SRI search of the literature, which

indicated that NASA-Marshall's ultrasonic technique was superior to any other known method for measuring stress. The innovator of the technique at NASA-Marshall wanted to test the device on tensile and compressive samples of several types of steel, so through the team's intervention the AAR provided wheel and rail samples.

Stress increments in the samples were successfully measured. Testing of sample materials was followed by measurement of actual railcar wheels, supplied by the FRA. Circumferentially and radially oriented shear wave velocity measurements were made through the rim of each wheel at locations spaced  $45^{\circ}$  apart. Similar determinations using a  $90^{\circ}$  change in shear wave polarization were also made. The difference between corresponding radial and circumferential time values was shown to represent stress (in the wheels).

Rail geometry accommodates residual stress measurements much better than the wheel configuration. New wheel rims contain high residual stresses and great material variability from wheel to wheel, but the last few inches near the end of each unwelded rail can serve as a convenient reference block since any residual stress is relatively low and material characteristics should be statistically representative of the entire rail. Thus, any measurement on a corresponding rail subsequent to welding will be a useful determination of total stress in the rail head and it will be within acceptable limits of accuracy.

A detailed report on this work has been recently published by NASA\* and is currently being evaluated by user agencies and some private sector firms involved in the fabrication of instruments capable of utilizing the technique. The SRI team has contacted the firm expressing the most interest in helping to commercialize the MSFC process and will maintain a supportive role throughout commercialization attempts. When a commercially available system is available, the team will act as intermediary

between the AAR and the supplier to ensure utilization of the technology.

#### A New Instrument for the Precise Profiling of Railways and Highways

New roadway measurement techniques are always of interest to highway and railway engineers. Currently used highway and railway profiling techniques employ equipment using a single-axis inertial reference (usually an accelerometer or a vertical gyro) in conjunction with other sensors to provide vehicle roll information or to compensate for vehicle body motion in the measured roadway profile data, or both.

During the course of its space program, NASA has reported considerable research and development on gyro-stabilized guidance and control systems. This work formed the basis for an improved method of acquiring and reducing railway and highway profile measurements--so important to engineering and safety.

The utility of currently used road or rail profilometers can be enhanced by the addition of a stable, platform-type inertial reference. A system including such a reference will allow the measurement of roll, pitch, yaw, and three-dimensional acceleration. By using elementary data reduction techniques, we can measure banks, bumps, curves, grades, elevations, speeds, and distances. By using somewhat more complex reduction methods, we can possibly determine power spectral densities (a measurement of distribution of the frequency and amplitude of roadway undulations), and other statistical measures that may be of interest. The important point is that, if the most nearly complete set of data practical is taken, it will be possible to obtain answers to future questions concerning the roadway simply by writing appropriate computer programs. Periodic data-gathering runs can be used to monitor the various forms of roadway degradations.

This type of improved data-collection system would make possible the measurement of several important track and roadbed characteristics of railways. These measurements would be obtained through the use of specially weighted cars located at advantageous positions in a train. If the system were mounted in a vehicle of average weight, a trajectory of the track could be obtained. Local characteristics (e.g., bumps) would be distorted by the suspension. On a springless vehicle, the trajectory and local characteristics would be obtained for the track loaded condition, while on a very light vehicle, the local characteristics would be obtained under virtually no-load conditions; comparison would give a measure of track foundation compliance. Additionally, the use of such a system on a railroad car could make more complete measurements of the interaction of railcars and track, and would probably be a useful tool for track/train dynamics studies.

For highways, the stable platform system would allow rapid verification of roadbeds before and after paving--a quality control advantage. The system would also measure shallow and steep grades, subgrade settlements, differential settlements, absolute elevations, banks, and curves. Speeds and distances traveled are also available from the data. The latter can be manually or automatically correlated with fixed, known landmarks. With noncontacting road-clearance sensors, runs for the purpose of studying vehicle response over the roadway should be practical at highway speeds.

NASA's Marshall Space Flight Center has considerable expertise in the design, development, and use of inertial systems. The team plans to involve MSFC scientists in the development of test vehicles for use in field trials to demonstrate this technology to railway and highway engineers. The MSFC laboratories have on hand the gyroscopes, accelerometers, vibration pickups, and vehicles, as well as the data reduction and mathematical modeling capability. Design and test information and the computer soft-



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ware can then be made available to potential manufacturers.

There is little doubt that the stable inertial platform, which has been used so effectively in the space program, can make a significant contribution to the safety and maintainability of roadways. A roadway measuring system based on the platform can also have a beneficial effect on generating and monitoring quantitative specifications for roadways, reduction of cargo damage, and reduced fuel consumption.

The SRI team plans to continue in its efforts of introducing this technology to interested public and private sector agencies. Next year's activities will include the development of a research and technology operating plan (RTOP) and locating adequate funding for its implementation.

#### A Safer Surface for Children's Playgrounds

Early in the year, the SRI team was informed of the City of Baltimore's need for a softer, more resilient playground surfacing material. Such a soft material would go far to decrease injuries to children from accidental falls and scrapes. It appeared to the team that NASA's thermoplastic propellant binder, suitably modified, would fulfill this need. The binder could be modified by the inclusion of recycled rubber to achieve any degree of softness desired. Additionally, if previously reported field results are correct, the material resists embrittling at low temperatures, giving it a longer winter lifetime.

The team arranged for U. S. Rubber Reclaiming Company, Vicksburg, Mississippi, to supply samples of specially formulated materials to Baltimore's Parks and Recreation Department. Working with Mr. Tom Golden, GSFC detailee to the City of Baltimore, an optimal formulation was selected. The material selected was noticeably softer than conventional asphalt mixes and exhibited good resistance to abrasion, thus

ensuring a relatively good service life.

Trial quantities of the material are now on hand in Baltimore and installation is scheduled for April 1975. The SRI team will be present during the installation, acting not only as transfer agent, but technical advisor as well. A successful trial in Baltimore should lead to widespread use of this material in playgrounds all over America.

### III NASA TECHNOLOGY APPLICATIONS:

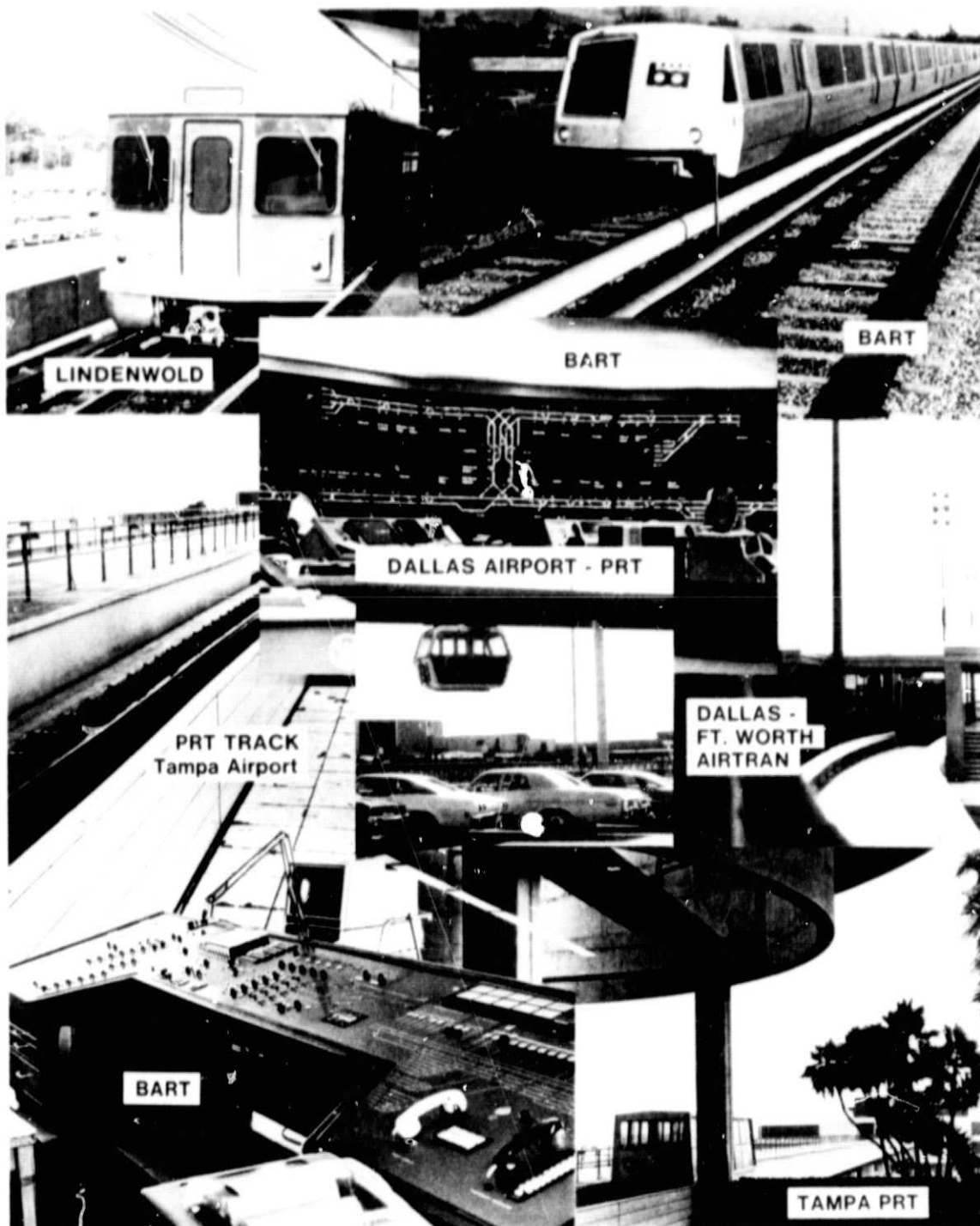
#### URBAN MASS TRANSPORTATION

During the past year, the SRI team expanded its activities to include investigation of problems in urban mass transportation systems. Contacts with three national agencies--The Urban Mass Transportation Administration (UMTA), DOT's Transportation Systems Center (TSC), and the Transit Development Corporation (TDC)--were established. All 10 of the established transit authorities in the United States were visited to explain the NASA TU program and gather operational problems potentially soluable by NASA-derived technology. These agencies included:

- Bay Area Rapid Transit District (BART)
- Chicago Transit Authority (CTA)
- Cleveland Transit System (CTS)
- Baltimore Mass Transit Administration
- Massachusetts Bay Transportation Authority (MBTA)
- Metropolitan Atlanta Rapid Transit Authority (MARTA)
- Metropolitan Transportation Authority (MTA) New York
- New York City Transit Authority (NYCTA)
- Port Authority Trans-Hudson Corporation (PATH)
- Southeastern Pennsylvania Transportation Authority (SEPTA)
- Washington Metropolitan Area Transit Authority (WMATA)

Visits were also made to the Lindenwold Line in New Jersey and the PRT (Personal Rapid Transit) lines at the Tampa and Dallas Airports. Figure 6 depicts some of these properties.

Specific problems of importance to the individual transit authorities, as well as those of interest to the entire industry, were compiled and



SA-3670-5

FIGURE 6 VIEWS OF SELECTED RAPID TRANSIT SYSTEMS

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presented in a special report entitled, "The NASA Technology Utilization Program Applied to Technical Problems in Urban Mass Transportation." Descriptions of the most pressing problems and their current statuses follow. It is expected that NASA will play a role in investigating flammability and system reliability problems.

Most of the problems listed below apply to rapid transit, but a few apply to buses. The problems are listed in order of greatest interest.

#### Fireproof Materials of Construction

Nonflammable, smokeless, nontoxic-gas-producing construction materials are needed for passenger safety in case of fire in a bus, rapid-transit car, or subway tunnel. Although current materials are acceptable under current fire standards, increased fire resistance is continually sought. Expertise within NASA's Ames Research Center will be drawn on for an objective evaluation of this problem and recommendation for future work. Active research efforts by Ames scientists should begin within the next year.

#### Smokeless Cables

The need for fireproof or self-extinguishing electric cable insulation that produces no smoke and minimal toxic gases when exposed to fire has become apparent in the rapid transit industry in the past few years. The need is especially important in closed locations, such as in cars and in tunnels. The blinding smoke and toxic gases evolved in such situations can pose a greater threat to passengers than the fire itself.

A preliminary technology survey of the NASA data base yielded nine report abstracts and six Tech Briefs. Materials for the reduction of electrical fire hazards (N72-16430), flame resistant electrical insulators

and accessories (A70-44461), nonflammable potting compounds (N72-16418), nonflammable materials for various uses (A71-44595 and A70-42295), and a versatile temperature resistant halar fluoropolymer (N73-23298) are all NASA originated. A flame retardant crosslinked polyethylene insulating jacket (N68-10817) and several severe environment, high temperature resistant cables (A69-16246 and N67-37329) are included for background information. The cables described in the Tech Briefs appear promising, but most of the materials discussed are very costly or not completely satisfactory. The team will work with Ames Research Center scientists on this problem, relating it to efforts under way on fireproof materials of construction. Possible coordination of Ames and TDC efforts may lead to a satisfactory solution to this problem within the next few years.

#### Scientific and Technical Aerospace Report (STAR) Abstract References

**N72-16430\*** National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.  
**MANNED SPACECRAFT ELECTRICAL FIRE SAFETY** c31  
 Anthony W. Wardell. In: *Conf. on Mater. for Improved Fire Safety* 1971 p 173-178 refs (See N72-16409 07-18)  
 Avail: NTIS: SOD \$2.25 CSCL 22B

The fire hazards created in spacecraft compartments by malfunction of electrical wiring are described. The tests for electrical wire/cable current overload flammability are presented. The application of electrical and material technologies to the reduction of fire hazards in spacecraft are examined. Author

**A70-44461\*** Development of nonmetallic materials for space applications. R. E. Smylie and E. L. Hays (NASA, Manned Spacecraft Center, Houston, Tex.). In: *Survival and Flight Equipment Association, Annual Symposium, 8th, Las Vegas, Nev., September 28-October 1, 1970, Proceedings, Volume 1*. (A70-44453 23-05) Van Nuys, Calif., Survival and Flight Equipment Association, 1970, p. 171-197.

Discussion of nonmetallic materials with improved flame-resistant properties developed by NASA and its industrial associates. Fibrous, cellulosic, elastomeric, and plastic materials have been developed. These basic materials have been used to produce fire-resistant fabrics, films, paper products, thermal and various electrical insulations, and other electrical accessories. These materials, either alone or in combination, also can be used to cover or coat flammable materials or substrates to render them fire resistant. In addition, they can be used to protect (by thermally insulating) or to contain flammable materials. Furthermore, use of these materials in original designs will result in nonflammable hardware items. G.R.

**N72-16418\*** National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.  
**DEVELOPMENT OF NONFLAMMABLE POTTING COMPOUNDS FOR SPACECRAFT**  
 Harry F. Kline. In: *Conf. on Mater. for Improved Fire Safety* 1971 p 83-90 refs (See N72-16409 07-18)  
 Avail: NTIS: SOD \$2.25 CSCL 11D

The requirements for nonflammable potting compounds for use in spacecraft electric and electronic equipment are discussed. The development of a suitable nonflammable compound is described. Flammability testing and acceptance criteria for Apollo spacecraft are presented. The dielectric properties of various ceramic materials used as conformal coatings are examined. Author

**A71-44595\*** Fire safety - An achievable goal. Matthew I. Radnoffsky (NASA, Manned Spacecraft Center, Crew Equipment Branch, Houston, Tex.). *American Institute of Aeronautics and Astronautics, Annual Meeting and Technical Display, 8th, Washington, D.C., Oct. 25-28, 1971, Paper 71-1011*. 11 p. Members, \$1.50; nonmembers, \$2.00.

The fire safety goals of NASA and the program plans for their achievement are discussed. Progress made in the development of nonflammable materials for both space and nonspace-oriented usage is described. Specifically, fibrous asbestos, glass, polyimides, Teflon, metallics, and halogenated materials are discussed. Fluoropolymers, nonflammable paper, and composite layups and their applications also are described. Material selection and fabrication processes for aircraft interiors, housing construction and interiors, and firefighters' suits are discussed. Material-application criteria such as flammability, weight, cost, durability, texture, color, decoration, fabrication, and installation considerations are presented as applicable. (Author)

**A70-42295\*** New materials for manned spacecraft, aircraft and other applications. Matthew I. Radnitsky (NASA, Manned Spacecraft Center, Supporting Development Branch, Houston, Tex.). *Air Line Pilot*, vol. 39, Sept. 1970, p. 25-32, 6 refs.

Discussion of the flame-resistant nonmetallic materials developed for manned-space applications taking into consideration the use of these materials in aircraft interiors and in other applications. Fibrous materials such as asbestos fiber, glass fiber, polyimide fiber, teflon fiber, metallic fibers, Durette fiber, Fypro, and Kynol are discussed, and fluoropolymers, nonflammable paper, and composite layouts are considered. G.R.

**N67-37329#** Andrew Corp., Chicago, Ill.  
**RESEARCH AND DEVELOPMENT OF HIGH TEMPERATURE, HIGH POWER, RADIO FREQUENCY, TRANSMISSION LINES FOR 350°C AND 825°C**  
 H. L. Woodbury [1963] 43 p refs Presented at 11th Ann. Symp. on Communc. Wires and Cables (Contract AF 33(616) 7389) (AD-656088)

The paper will describe the development of two high temperature, low-loss, coaxial cables for operation in the -65 to 350°C and -100 to 825°C temperature ranges. These cables were developed primarily for use on aircraft, missiles and space vehicles. The high temperature requirements exist because the cable path may lead from the relatively cool areas of cockpit environments to the extremely hot external surfaces of a vehicle. TAB

**N73-23298\*** Allied Chemical Corp., Morristown, N.J.  
**HALAR FLUOROPOLYMER: A VERSATILE INSULATION MATERIAL**  
 A. B. Robertson In NASA, Marshall Space Flight Center Flat Conductor Cable Symp., 8 Dec. 1972 14 p (For availability see N73-23294 14-09) CSCL 11D

Research directed toward developing materials for the wire and cable industry has resulted in a new product, E-CTFE copolymer, which has an outstanding combination of electrical, thermal, and mechanical properties. The properties of E-CTFE are discussed and compared with those of other commercial fluoropolymers. Particular attention is given to the utility of E-CTFE as a wire and cable insulation. Author

**N58-10817#** Furukawa Electric Co. Ltd., Tokyo (Japan).  
**FLAME RETARDANT CROSSLINKED POLYETHYLENE FOR WIRE AND CABLE**

Tsunemi Yoshida, Reikichi Nakayama, and Tadaaki Kohara [1967] 18 p refs Presented at the 16th Ann. Wire and Cable Symp., Atlantic City, N. J., 29-30 Nov.-1 Dec. 1967 (AD-659412)

The report relates to a flame retardant crosslinked polyethylene which was recently developed for use in insulating and jacketing electric wires and cables. It is widely known that by merely adding crosslinking agent to a conventional flame retardant polyethylene compound, several desirable properties cannot be attainable. Therefore, studies have been carried out on additives for fully effecting crosslink reaction, and additives for improving flame retardancy of the product. The new compound obtained through these studies not only possesses an excellent flame retardancy, which is evaluated in accordance with ASTM D-635 to be 'self-extinguishing' or 'non-burning', but it also has a high degree of crosslinking and outstanding electric characteristics. apparatus lead wires, drop wires and power cables insulated with this new compound have passed the vertical flame test by the UL method. The new compound is shown to have many outstanding practical properties. Author (TAB)

**A69-16246**  
**CABLE ASSEMBLIES FOR THE F-111 AIRCRAFT.**  
 George Voda (Sandia Corp., Sandia Laboratory, Albuquerque, N. Mex.).  
 IN: **ELECTRICAL INSULATION CONFERENCE, 8TH, LOS ANGELES, CALIF., DECEMBER 9-12, 1968, PROCEEDINGS.** [A69-16240 05-09]

Conference sponsored by the Institute of Electrical and Electronics Engineers, the National Electrical Manufacturers Association, and the U.S. Navy.

New York, Institute of Electrical and Electronics Engineers, Inc., 1968, p. 45-48, 10 refs. AEC-supported research.

Description of the design, testing, and manufacturing processes involved in the development of interconnecting cables for externally mounted armament in the F-111 aircraft. Due to the exposed position of the cables, they are subject to a variety of environmental factors, and the design had to allow for high heat resistance, resistance to fuel spillage, vibration, altitude, moisture, abrasion, mechanical shock, sharp bending, hot gases, and salt spray. Since all the desired properties could not be achieved with currently available materials, a series of tradeoffs had to be instituted. In order to survive the operational and environmental extremes, PTFE insulated conductor wire, fluorosilicone rubber jacketed cable, Sh 5 assembly solder, temperature resistant sealants and potting compounds, a specially designed miniature relay, and other suitable materials were selected. The materials testing before manufacture, and the product testing after manufacture, are described, along with the solutions to some production problems encountered. G.V.

### Fire Extinguishing Equipment

On-board fires have become an increasingly important problem for rapid transit authorities. Recent fires in subway tunnels have resulted in considerable property damage, injuries to the public and several deaths. To protect life and property from potential fires, compact, efficient fire extinguishment systems are needed for the underside of the car and for the dropped ceiling areas within the car.

NASA-Ames Research Center is working on aircraft fire extinguishing systems that have potential for direct application to rapid transit cars. Concentration is on solid rather than liquid extinguishers to reduce toxic gas emission. A technology survey also produced eight abstracts concerned mainly with aircraft fire extinguishment. Although none of these abstracts were NASA originated, they provided useful background information. The feasibility of using the NASA-derived aircraft systems is currently under investigation.

### System Reliability Design

Strong interest in NASA's capabilities with system reliability was expressed by several rapid transit agencies. Backup systems, so essential to successful space missions, are also needed for a failsafe transit operation.

One very basic tool from NASA is the Automated Verification of Redundant Systems (Tech Brief 72-10295) to determine whether the redundancy is present, the component/circuitry is working, and the redundancy complement has degraded.

The team is currently studying the efficacy of applying the aerospace style of quality control and systems reliability methodologies to public transit systems. If the feasibility of this approach is demon-



strated, the team will coordinate the involved DoT and NASA personnel in a joint program to generate guidelines and procedures for rapid transit use.

#### New Computer Programs

Transit Car Diagnostic System--the transit industry's desire for less downtime might be realized through the use of a computerized diagnostic system for transit cars. Monitoring and analysis systems of a similar nature were developed for the Apollo program to display engineering information. In fact, the success of the spacecraft's adjustment to its environment can be attributed to the limited control feedback function. Consideration is being given to adapting these systems to the transit car.

Transit-Related Dynamics Studies--a possible direct transfer was initiated following a request by the New York City Transit Authority (NYCTA) for more information on the NASA-Langley computer program, The Digital Time Series Analysis Program (Contract No. NAS1-5631 and I.D. No. R-1299). The team contacted the Langley TU office and obtained the requested information. The NYCTA is now working directly with the Langley TU office to determine if the Langley program can be applied to NYCTA use. The team will follow the progress of this work and provide any assistance that may be needed.

#### Shatterproof Windows

From the standpoint of safety, maintenance, and repair, bus and rapid transit windows are a major concern of operators. Windows broken by rocks thrown at passing buses and rapid transit cars and from road debris present both safety hazards and an economic burden. The need for shatterproof, abrasion-resistant, optically clear materials for use

in windows has been demonstrated. Although materials are currently available that claim to meet this need, none has proven totally acceptable.

A research and development program currently under way at NASA-Ames Research Center is involved in the fabrication of impact-resistant, fire-safe plastic windows for commercial aircraft. An expected benefit from this program will be the development of a more shatter-resistant plastic window material for bus and rapid transit car application. The SRI team will work with Ames Research Center scientists to transfer this technology once the adaptive engineering program is successfully accomplished.

Other problem areas:

#### Improved Fire Detection Systems

Early warning of incipient fire and quick extinguishment response requires an accurate on-board fire detection system. Such a system should be fail-safe, vandalproof, and inexpensive, as it should be installed on every car. A computerized evaluation and recommendation system tied in with the detection system such as shown in Figure 7, has also been suggested.

NASA-Ames Research Center is working with fire detection systems for use on aircraft that potentially have direct application for rapid transit car use. A technology survey uncovered 12 abstracts concerned mainly with heat, combustion, and UV radiation detection. None of the abstracts uncovered were NASA originated. The results of the survey were made available to the user community.

#### Acoustic Materials

The high sound level experienced in subway tunnels is unattractive to passengers. Current systems operate as much as 20 to 30 decibels above the requirements specified by the systems under construction.



To reduce the noise level inside trains traveling through tunnels, a sound-absorbing material for treatment of tunnel walls is desired that could be installed on the interior walls of fan shafts, vent shafts, and line sections. A spray-on, asbestos-free, cementitious material, easily applied to concrete and metal surfaces, would be useful. A thickness of 1 inch should have minimum acoustical properties of a 0.45 sound absorption coefficient (SAC) at a 250 octave band center frequency (OBCF), a 0.70 SAC at a 500 OBCF, and a 0.85 SAC at a 1,000 OBCF. In addition, the material should be fire resistant, rodent proof, washable, durable, and abrasion resistant.

A technology survey revealed abstracts relating to the use of composites, polyurethane foam, fiberglass, and a latex coating as sound absorbing materials. The results also included information on duct acoustic lining techniques and sources of noise in rapid transit systems. The team's transit users were informed of the results of the survey but none were really able to act due to budget and timing constraints.

#### Improved Air Conditioners

Air-conditioning systems currently in use consume one-third of the power supply for transit cars, and are bulky; therefore, more efficient refrigerants and smaller units are desired. In addition, several system components need improvements to reduce maintenance time and expense. Items desired include a technique to halt oil migration from the compressor to other car components, means to store waste power, controls to provide a response to 600-volt transients, a static humidistat, and a disposable air filter.

A technology survey of air-conditioning systems produced seven abstracts dealing mainly with aircraft and space systems. A NASA-derived integrated temperature control and humidity control is described in

A70-40998. A computerized model of thermal control weight and power requirements (A69-33305) and a study of the properties of refrigerants (N68-21357 and N70-21411) may be useful. Small components developed as a result of weight and space restrictions (A73-36340), proven components and concepts (A67-30374), and integration of system design parameters into a properly functioning overall system (A69-24505) are also included in the survey.

**A70-40998 \*** Integrated temperature control, humidity control, and water recovery subsystem for a 90-day Space-Station Simulator test. G. E. Allen, M. S. Bonura, E. C. Thomas, and D. F. Putnam (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). In: Space systems and thermal technology for the 70's. American Society of Mechanical Engineers, Space Technology and Heat Transfer Conference, Los Angeles, Calif., June 21-24, 1970. Proceedings. Part 1. (A70-40976 21-31) New York, American Society of Mechanical Engineers, 1970. 6 p. 8 refs. Research sponsored by the McDonnell Douglas Astronautics Independent Research and Development Program; Contracts No. NASw-1612; No. NAS 1-8997.

This paper describes the integrated temperature control, humidity control, and water recovery subsystem provided for a 90-day manned test in the McDonnell Douglas Space Station Simulator (SSS). The design was evolved over the last six years and incorporates the lessons learned from more than 3600 hours of bench testing, and 143 days of manned chamber testing. The subsystem was designed to perform three major functions: (1) maintain total comfort in terms of temperature and humidity, (2) provide all potable water for the crew, and (3) accommodate tests to provide design criteria for a real space station. The realistic configuration could be used in a space station application. It is compact, highly reliable, easy to maintain, suitable to many cabin pressures and atmospheric gases, and adaptable to both performance and component modifications. (Author)

**N70-21411#** National Bureau of Standards, Boulder, Colo. Cryogenics Div.

#### REFRIGERATION TECHNIQUES

T. H. Stronbridge. 1969. 18 p. Presented at the Helium Appl. Symp., Washington, D.C., 23-24 Oct. 1968 and at the Helium Centennial Symp., Atlantic City, 11 Sep. 1968. Submitted for publication.

(PB-183214, BM-4C 8417, H-540) Avail. CFSTI CSCL 13A

Contents: introduction-helium as a refrigerant; The relationship of refrigerators and liquefiers; Counterflow heat exchangers; The Joule-Thompson process; The Brayton and Claude cycles; Expanders; The Gifford-McMahon cycle; Modern refrigerators and liquefiers.

USGRO

**A73-36310 #** Fulfilling the potential of the SRAM air conditioner. A. E. Nurnen (Boeing Aerospace Co., Seattle, Wash.). *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 8th, Palm Springs, Calif., July 16-18, 1973, Paper 22-222*. 11 p. Members, \$1.50; nonmembers, \$2.00.

The Short Range Attack Missile (SRAM) weapons system includes an air conditioner, in the B-52 carrier airplane, to cool missiles and carrier avionics. High flight speeds at low altitude, summer temperatures and low missile and avionics temperature tolerance led to high thermal potential as a design requirement. Weight and space restrictions dictated small components. Problems with Freon refrigerant and air distribution in the heat exchangers and variability of components are discussed. Air conditioner performance trends, and sensitivity to internal and external operating conditions are presented. Following intensive experimental problem solving and performance evaluation the thermal potential requirement was fully met. (Author)

**N68-21357#** Royal Aircraft Establishment, Farnborough (England). **NOTES ON THE SELECTION OF OF REFRIGERANTS FOR AIRCRAFT VAPOUR CYCLE COOLING SYSTEMS**. E. A. Timby. Jun. 1967. 42 p. refs.

(RAE TR 67147) CFSTI HC \$3.00/MF \$0.65

The properties of a number of refrigerants have been studied and the theoretical performance of the refrigerants most likely for airborne use considered. Choice would depend upon the specific requirements for any system, probably lying between refrigerants R12 and R114. No existing refrigerant is suitable for use at condensing temperatures over 90°C. More information is needed on stability and corrosion at elevated temperatures and on mixtures of refrigerants known as azeotropes. (Author)

#### A69-24505

**MODULAR HYDRAULIC POWER SYSTEMS FOR GENERAL AVIATION.**

Herbert W. Pepper and Charles E. Rees, Jr. (International Telephone and Telegraph Corp., ITT Aerospace Controls, Burbank, Calif.).

*Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 26-28, 1969, Paper 696329*. 9 p. Members, \$1.00; nonmembers, \$1.50.

Discussion of a concise and factual solution to the design selection, phase-in, and customer acceptance problems of equipping aircraft with hydraulic power sources. It is pointed out that renewed emphasis on hydraulic power for use in general aviation has increased the need for modularized hydraulic pumping systems in order to reduce the complexity levels of "multiple plumbed built to order" hydraulic systems. (Author)

G. R.

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**A69-33305 #**

**PARAMETERS THERMAL CONTROL REQUIREMENTS FOR  
FULL RECAPITULATION**

R. S. Barker and S. W. Taylor of McDonnell Douglas Corp., McDonnell  
Douglas Astronautics Co., Wash. D.C., Boston, Mass., California  
Aeronautics Institute of Technology and Aerospace Corp., Los Angeles  
California, 4th, San Francisco, California, Wash. D.C., Paper  
No. 69-11, 11 pp. 8 refs.

Members, \$1.00; nonmembers, \$1.50.

Computed thermal control weight and power requirement data  
for a group of complete support system problems formulated for  
determining relative importance of these thermal control require-  
ments to pertinent independent variables. The independent vari-  
ables considered include number of occupied cabins, variations in  
crew activity level, variations in heating and cooling requirements  
for life support system equipment, closure of the life support  
system in terms of regeneration of water and oxygen, and number  
of crew members. Models for thermal control equipment sized for  
the analyses include cabin exchangers, condensing heat exchangers,  
cabin wall insulation, liquid cooling and heating loops, and space-  
radiator loops. For the assumed vehicle geometries, the cabin  
wall insulation contributed large portions of the total weights. The  
space-radiator loops contributed significantly to the total weights  
when availability of space-radiator surface area was limited. It is  
shown that variations in crew activity level and other variables  
result in appreciable weight and power variations. Thermal control  
equipment is shown to comprise significant portions of total life  
support system weight and power requirements. Sample tradeoff  
plots are presented for three life support systems. (Author)

**A67-30374 #**

**DC-9 ENVIRONMENTAL CONTROL DESIGN AND FIRST YEAR'S  
SERVICE EXPERIENCES.**

H. H. Hauger, V. F. Cleaves, and J. S. Perlee (Douglas Aircraft  
Co., Inc., Long Beach, Calif.).

American Institute of Aeronautics and Astronautics, Commercial  
Aircraft Design and Operation Meeting, Los Angeles, Calif., June  
12-14, 1967, Paper 67-107, 11 pp.

Members, \$0.75; nonmembers, \$1.50.

The design of the environmental control systems for the DC-9  
was greatly influenced by the availability of clean engine bleed air  
for cabin pressurization and by the use of an onboard auxiliary  
power unit as a source of energy for ground air conditioning. The  
service problems associated with existing jet transports were scruti-  
nized in depth at the start of the DC-9 design so that marginally  
reliable components could be avoided and only the proven components  
and concepts perpetuated. As a result of an intense desire to simpli-  
fy the systems and controls to the optimum extent, engine bleed air  
is extracted at the lowest practical pressure, air cycle equipment  
refrigerates the cabin air, and continuous anti-icing is accomplished  
for the wing airfoil surfaces. A manually operated defrost cycle  
removes ice from the horizontal stabilizer. Temperature control  
for the cabin air supply merely bypasses the refrigeration unit in  
one step, allowing ram cooling air to continue uncontrolled through  
the heat exchangers. The results of the first year's airline service  
experience substantiated the design concepts in that, for the most  
excellent reliability was achieved and guaranteed performance was  
met. Delays in trip departure associated with the environmental  
control systems will meet the desired goal of 1.2 delays per 1000  
departures. (Author)

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**A69-33305 #**

**PARAMETRIC THERMAL CONTROL REQUIREMENTS FOR FUTURE SPACECRAFT.**

R. S. Barker and S. W. Nicol (McDonnell Douglas Corp., McDonnell Douglas Astronautics Co., Western Div., Huntington Beach, Calif.). American Institute of Aeronautics and Astronautics, Thermophysics Conference, 4th, San Francisco, Calif., June 10-12, 1967, Paper 70-21, 11 p., 8 refs.

Members, \$1.00; nonmembers, \$1.50.

Computed thermal control weight and power requirement data for a group of sample life support system problems formulated for determining relative sensitivities of these thermal control requirements to pertinent independent variables. The independent variables considered include number of occupied cabins, variations in crew activity level, variations in heating and cooling requirements for life support system equipment, closure of the life support system in terms of regeneration of water and oxygen, and number of crew members. Models for thermal control equipment sized for the analyses include cabin exchangers, condensing heat exchangers, cabin wall insulation, liquid cooling and heating loops, and space-radiator loops. For the assumed vehicle geometries, the cabin wall insulation contributed large portions of the total weights. The space-radiator loops contributed significantly to the total weights when availability of space-radiator surface area was limited. It is shown that variations in crew activity level and other variables result in appreciable weight and power variations. Thermal control equipment is shown to comprise significant portions of total life support system weight and power requirements. Sample tradeoff plots are presented for three life support systems. (Author).

**A67-30374 #**

**DC-9 ENVIRONMENTAL CONTROL DESIGN AND FIRST YEAR'S SERVICE EXPERIENCES.**

H. H. Hauger, V. F. Cleaves, and J. S. Perlee (Douglas Aircraft Co., Inc., Long Beach, Calif.). American Institute of Aeronautics and Astronautics, Commercial Aircraft Design and Operation Meeting, Los Angeles, Calif., June 12-14, 1967, Paper 67-107, 11 p.

Members, \$0.75; nonmembers, \$1.50.

The design of the environmental control systems for the DC-9 was greatly influenced by the availability of clean engine bleed air for cabin pressurization and by the use of an onboard auxiliary power unit as a source of energy for ground air conditioning. The service problems associated with existing jet transports were scrutinized in depth at the start of the DC-9 design so that marginally reliable components could be avoided and only the proven components and concepts perpetuated. As a result of an intense desire to simplify the system and controls to the optimum extent, engine bleed air is extracted at the lowest practical pressure, air cycle equipment refrigerates the cabin air, and continuous anti-icing is accomplished for the wing airfoil surfaces. A manually operated deicing cycle removes ice from the horizontal stabilizer. Temperature control for the cabin air supply merely bypasses the refrigeration unit in one step, allowing ram cooling air to continue uncontrolled through the heat exchangers. The results of the first year's airline service experience substantiated the design concepts in that, for the main, excellent reliability was achieved and guaranteed performance was met. Delays in trip departure associated with the environmental control systems will meet the desired goal of 1.2 delays per 1000 departures. (Author)

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The transit properties are currently evaluating these briefs. The team will coordinate follow-on activities as the properties' budgets and timing constraints allow.

Problems of a somewhat lower priority under the team's consideration include:

#### Encroachment Detection and Response

Sections of some rapid transit system rights-of-way parallel railroad rights-of-way. In the case of a railroad derailment or other rapid transit track encroachment, a detection and quick response system is needed to alert the control operator (Figure 8) and halt rapid transit trains approaching the blockage.

#### Fare Collection System

A compact, foolproof variable fare collection system is needed. The magnetic tape tickets now used can be altered and reused.

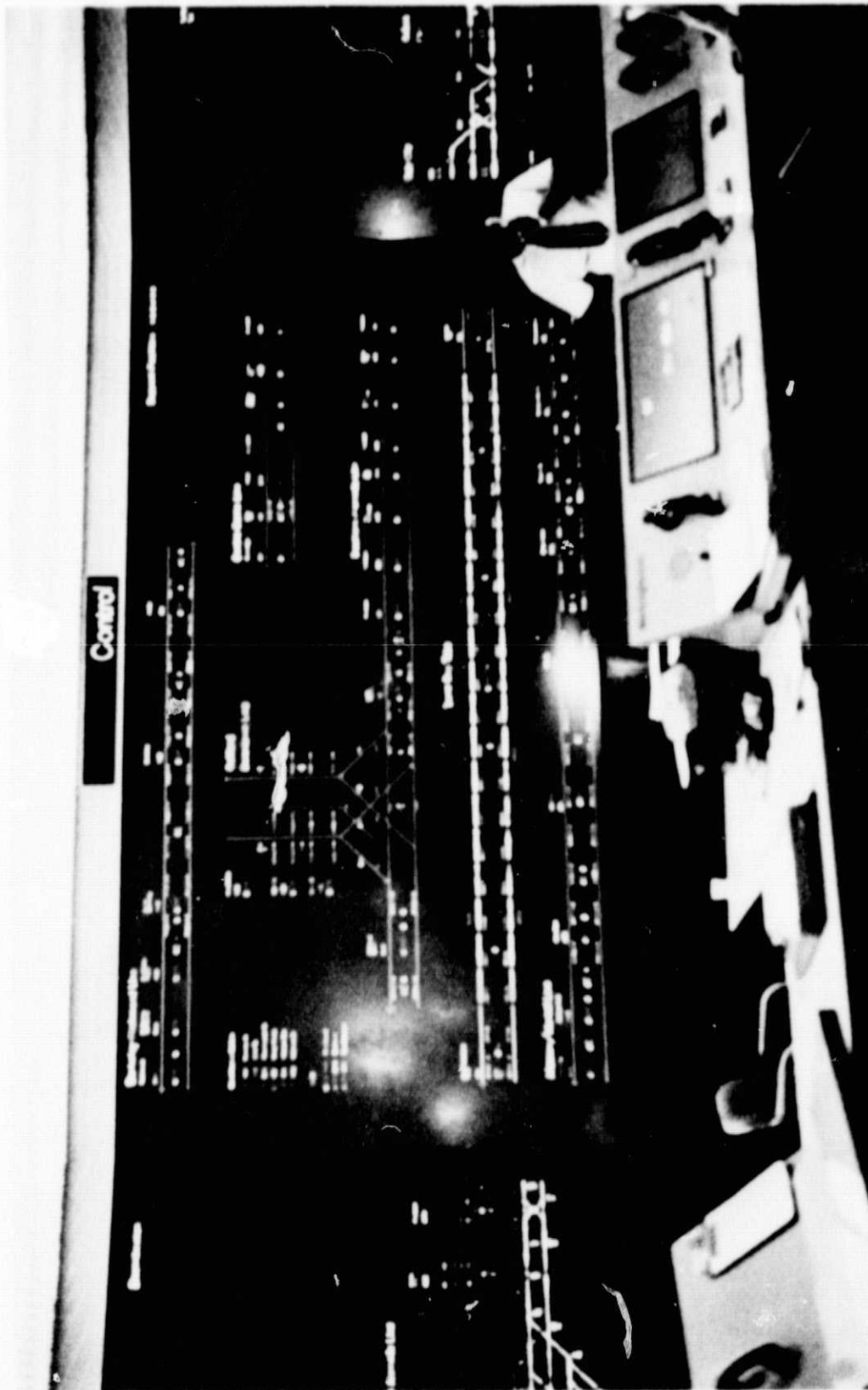
#### Signal Connectors

To decrease maintenance and increase electrical operation, improved between-car signal connectors are desired. Both improved mechanical alignment and more reliable electrical connection are needed.

#### Improved Braking System

For more effective braking, rapid transit cars need better wheel-to-rail adhesion and an improved braking system. Such a system should be less sensitive than systems currently used to curtail sliding, and also to provide greater maximum braking rates. A system check and per-





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FIGURE 8 CONTROL OPERATOR'S VIEW OF TRANSIT SYSTEM

formance monitor is also desired. An improved slip-slide control has been suggested as well as a system to automatically determine the track coefficient of friction (with variable weather conditions) to adjust banking rates. Elimination of sliding would also curtail flat and spalling wheel problems.

#### Third Rail Deicer

Ice can build up as thick as 3/8 inch on an outside third rail during the winter months. A buildup as thin as 1/16 inch will stop trains by insulating the third rail power from the train, and sleet scrapers, oil, and lamps have not satisfactorily solved this problem.

#### IV PROGRAM VISIBILITY

Presentations to two professional associations were given by team members during May. In an after-dinner talk, Mr. James Wilhelm described, "The NASA Technology Utilization Program Applied to Railroad and Rail Transit Problems," to the Metropolitan Railway Club of New York at their quarterly meeting (May 9, 1974). He covered the history of the TU effort, the SRI TAT transfer methodology, and several past and present transfers of technology to the railroad and rail transit industries. Mrs. Ruth Lizak was a speaker at the Western Regional Conference of the American Public Works Association, held in Anaheim, California on May 19-23, 1974. She used two case studies (NASA's randomdec technique for bridge inspection and improved friction material for brake linings) to illustrate the transfer process--the "how" of technology transfer--and the interrelationship of user agency, NASA innovator, funding agency, and private company.

In its attempt to broaden its coverage and be responsive to a greater number of problems and users, the SRI team issued two volumes of "Technology Applications Notes." The newsletters were mailed to the president of every railroad employing over 5,000 employees and to representatives of 50 state highway departments. It is the team's hope that this publication will give the NASA program increased visibility with potential users and will generate new and interesting problem areas for solution by the application of NASA technology. In addition, an article, describing NASA's Technology Utilization Program and the SRI team's role in it, appeared in the Fall 1973 issue of Institute for Transportation Newsletter. This and other illustrations of team visibility are shown in Figure 9.



# intercom

NO. 237  
SEPTEMBER 20, 1974

TEC 17C

San Francisco Chronicle  
Charles de Young Trust: Editor and Publisher  
George T. Cameron, Publisher 1923 to  
Founded 1869 by Charles and M. ...

October 21, 1973

## Benefits of Space TECHNOLOGY APPLICATIONS NOTES

ABOUT THE weather aren't as fun-  
used to be. As any television  
viewer can see, the weather  
forecast is now more accurate  
than ever before.

The National Aeronautics  
and Space Administration  
Office of this effort mat-  
ch the aerospace knowl-  
edge of this effort mat-

Technology Applications Team  
Stanford Research Institute  
Menlo Park, California 94025  
Number 1 September 1973

## TECHNOLOGY APPLICATIONS NOTES

NASA Technology Applications Team  
Stanford Research Institute  
Menlo Park, California 94025  
2 November 1973

INSTITUTE FOR TRANSPORTATION  
of the AMERICAN PUBLIC WORKS ASSOCIATION

## NEWSLETTER

Vol. 1 / Number 3

Fall 1973

### NASA TO SHARE INFO

The National Aeronautics and Space Administration's Technology Utilization Office hopes to transfer technology gained from the US aerospace program to other areas. One aspect matches public agency problems with solutions in the aerospace knowledge bank. A Technology Applications Team (TAT) performs this function at inter-disciplinary research institutes, with public-sector representatives and NASA scientists and engineers.

At Stanford Research Institute, a NASA team is working to help solve transportation problems. Coupled with this mission is the development and application of methodology to achieve such transfer, particularly in the area of

### Space age technology solves transit problems

Locally, the team is working with BART engineers to help improve BART's control systems and to identify and apply BART with more resistant car materials.

The team, according to Program Director Tom is able to find these answers by drawing on information stored in a database believed to be the largest bank of scientific engineering data ever technical and that exists. The team worked with 32 transportation agencies and NASA innovation for railway

Association and the Federal Administration are the unique technology acquisition.

of Notes by the  
Stanford Research Institute  
to serve  
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ENGINEERING NEWS  
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NOV 5 1973

### New way to restore serial numbers

Stanley G. Young of the National Aeronautics and Space Administration has worked out a new means of restoring serial numbers when criminals have removed them from stolen metal goods by grinding or filing. Young is at NASA's Lewis Research Center, Cleveland, Ohio. His method is based on cavitation, the formation of teeny vacuumlike cavities as a result of uneven pressure gradients in a liquid. The NASA team described the method at a seminar

The new technique grew from an ultrasonic etching process developed by Young for metalographic studies of alloys. A NASA technology transfer team at Stanford Research Institute, Menlo Park, Calif., suggested it use in restoring serial numbers. Young tried it, and it worked. In the course of the effort, he found that brass appeared on a sample of numbers restored on a sand image, rather than in a sand-cavitation attack may be relative to the microstructure of the material that re-

CLIPPED BY  
BACONS

FIGURE 9 ILLUSTRATIONS OF TEAM VISIBILITY ACTIVITIES

## V CONCLUSIONS AND RECOMMENDATIONS

The importance of the adaptive engineering and business opportunity phases of the transfer process has been stressed repeatedly by the SRI team. Usually both phases must be pursued and completed before a transfer of a given technology is possible. The adaptive engineering program must be so designed as to reduce the newly developed or advanced technology to its most cost-effective state, while the business opportunity plan has to be designed with the industrial investor in mind. The plan must recognize that the investor's greatest incentive for involvement in a new technology is his opportunity to make a profit. The more clearly this potential is demonstrated, the more readily will the private sector involve itself in the transfer process.

During the current contract, the SRI team has sought funding for adaptive engineering projects from the Technology Utilization Office of NASA, from the U. S. Department of Transportation (i.e., Transportation Systems Center, Federal Railroad Administration (through the Association of American Railroads), and the Federal Highway Administration) and other federal and private agencies. In many cases, such as those outlined in this report, the team was successful. A number of others, however, are still in the planning phases. The time lags while these planning phases develop severely hinder the transfer process. The team sees no way to alleviate this problem as it is tied so closely to federal procurement and requisitioning policies.

It has become increasingly evident that the product development function is the recognized responsibility of the private sector. The adaptive engineering necessary to develop an aerospace-derived technology to a

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commercially viable stage, however, must be federally funded (for the most part) if a transfer is to be accomplished.

The SRI team feels it has further strengthened its ability to find and transfer key NASA--derived technology, and looks for continued interaction with federal agencies, private industry, NASA centers, and the TU office. The team believes that NASA has indeed become the forerunner in the transfer of technology to benefit mankind and that this position will be maintained.